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E21B 47/12 17/02 , H01R 13/523 13/533

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US 3807502 A

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INT CL[6] E21B
Online: WPI

(54) Method of making and breaking electrical connections

(57) A method of making and breaking electrical connections in a wireline connecting electrical equipment down a wellbore to surface electrical equipment includes providing a plurality of electrically connectable sections, each section including a male member 12 and a female member 11 respectively at opposite ends thereof, sequentially lowering the sections down the well to interconnect the male and female members of sequential sections and make an electrical connection therebetween; and sequentially raising the sections in the well to decouple the male and female members of sequential sections and break the electrical connections therebetween.

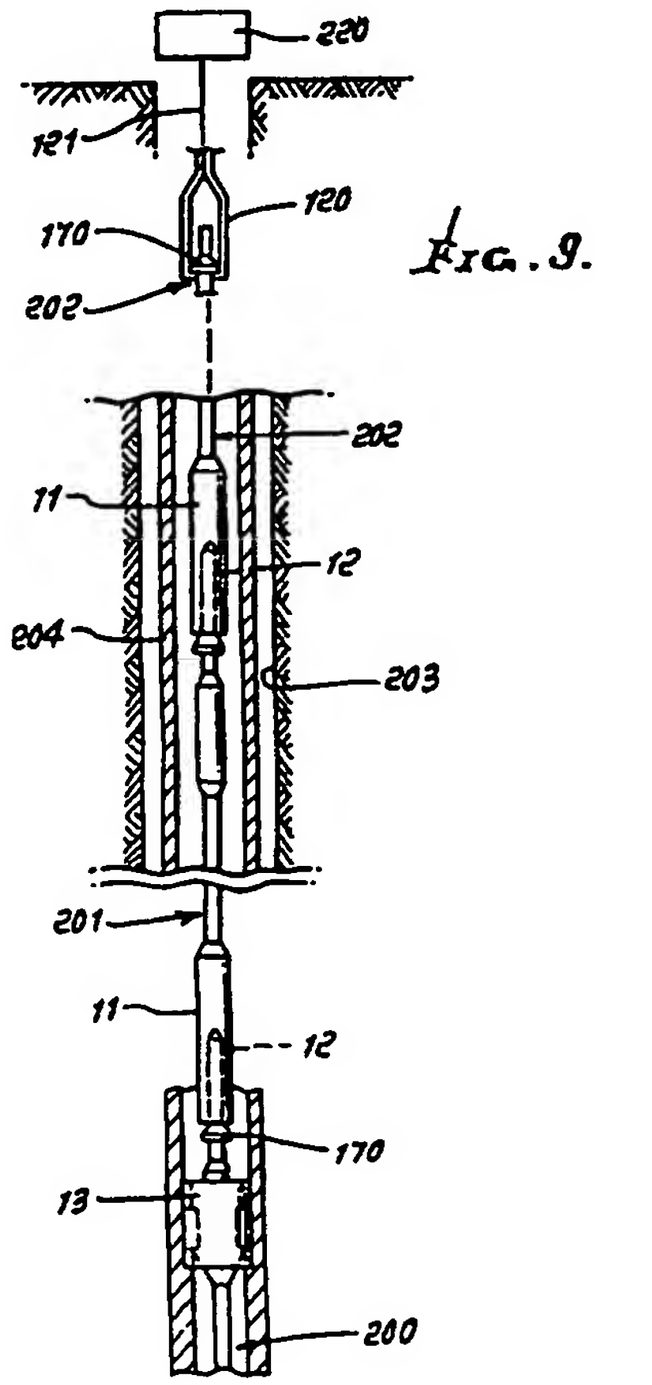

Fig. 9.

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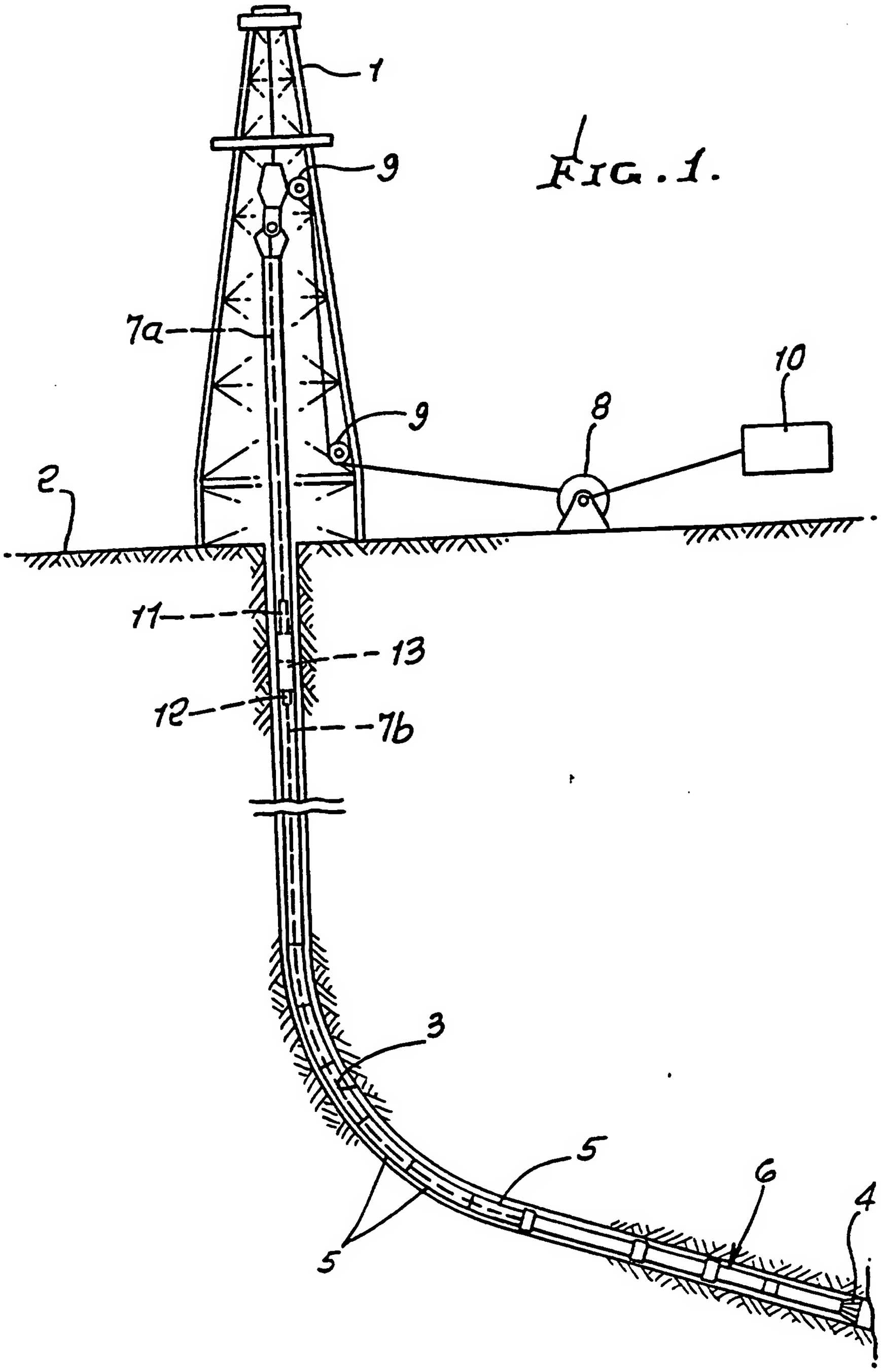


FIG. 1.

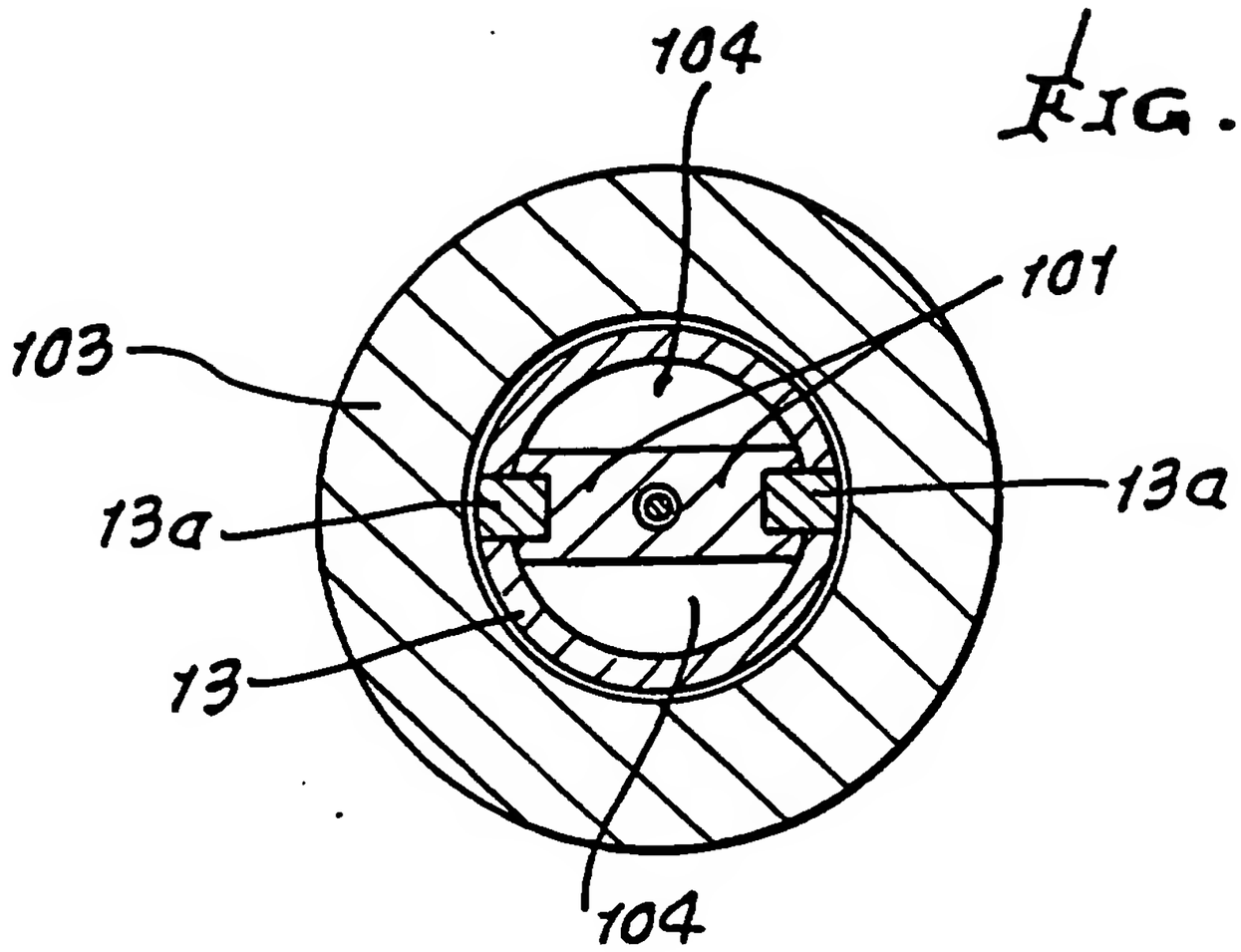


FIG. 2a.

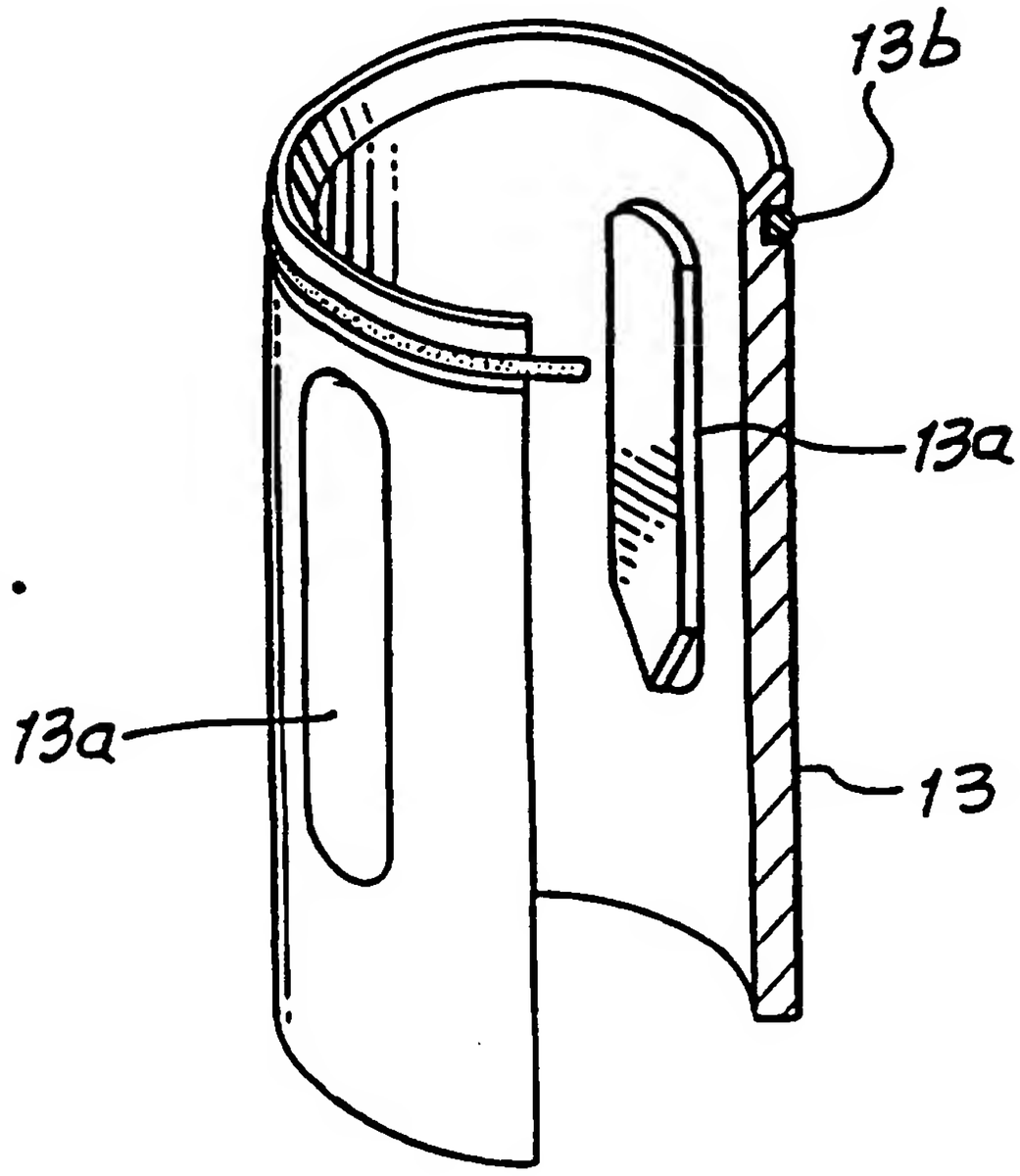


FIG. 2b.

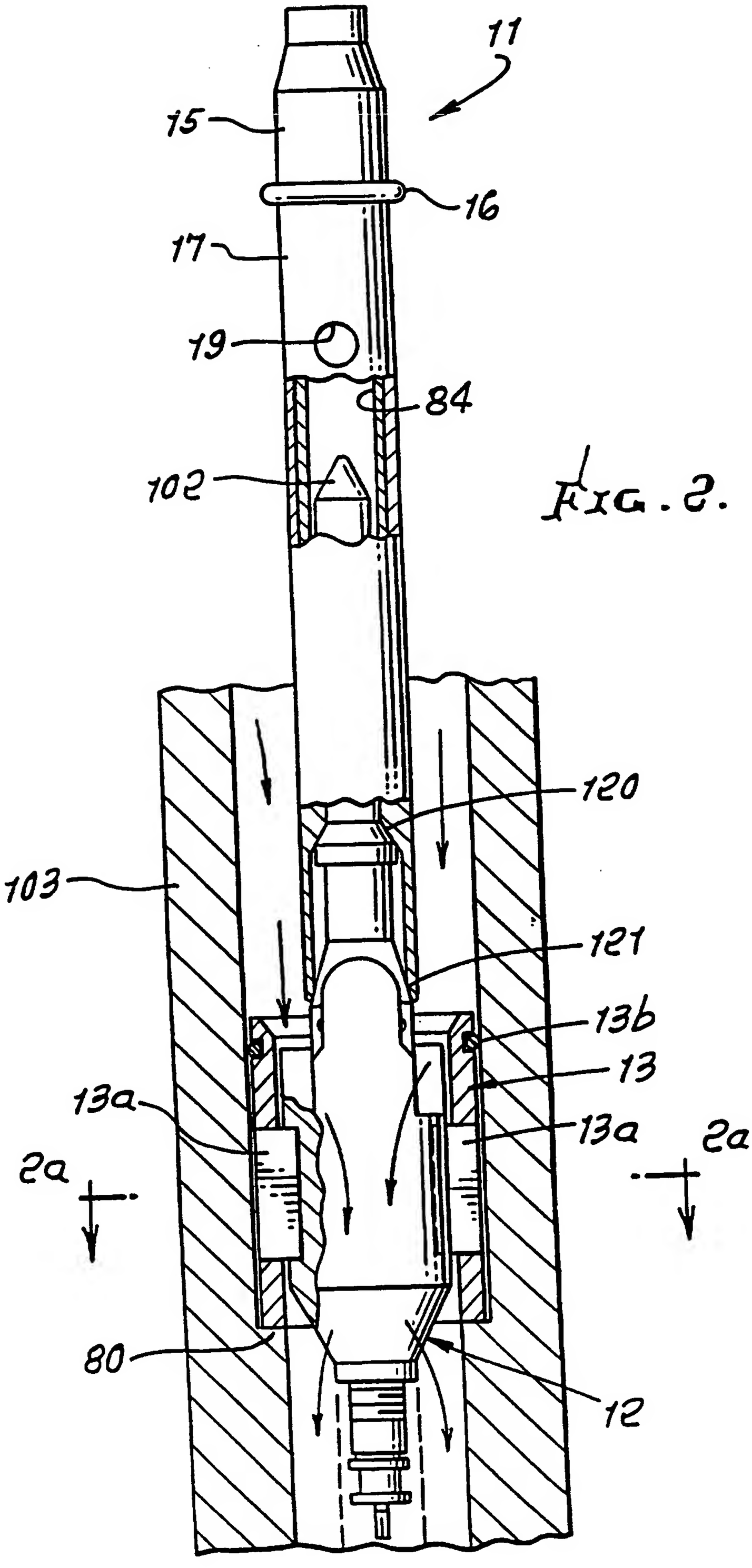


FIG. 2.

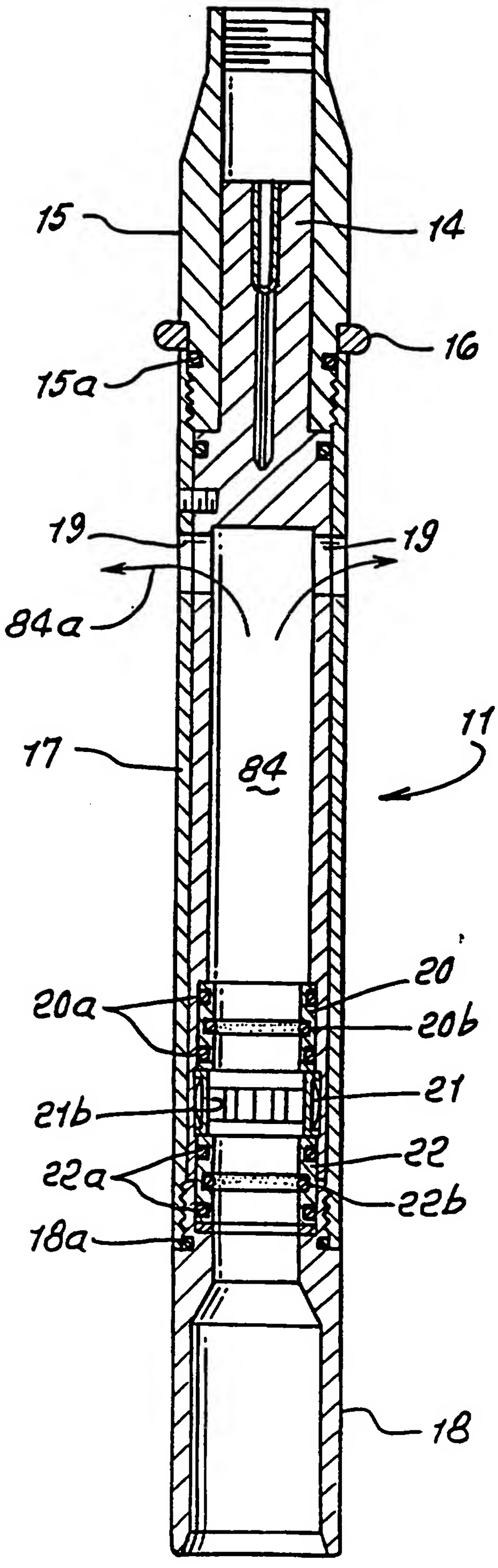


FIG. 3.

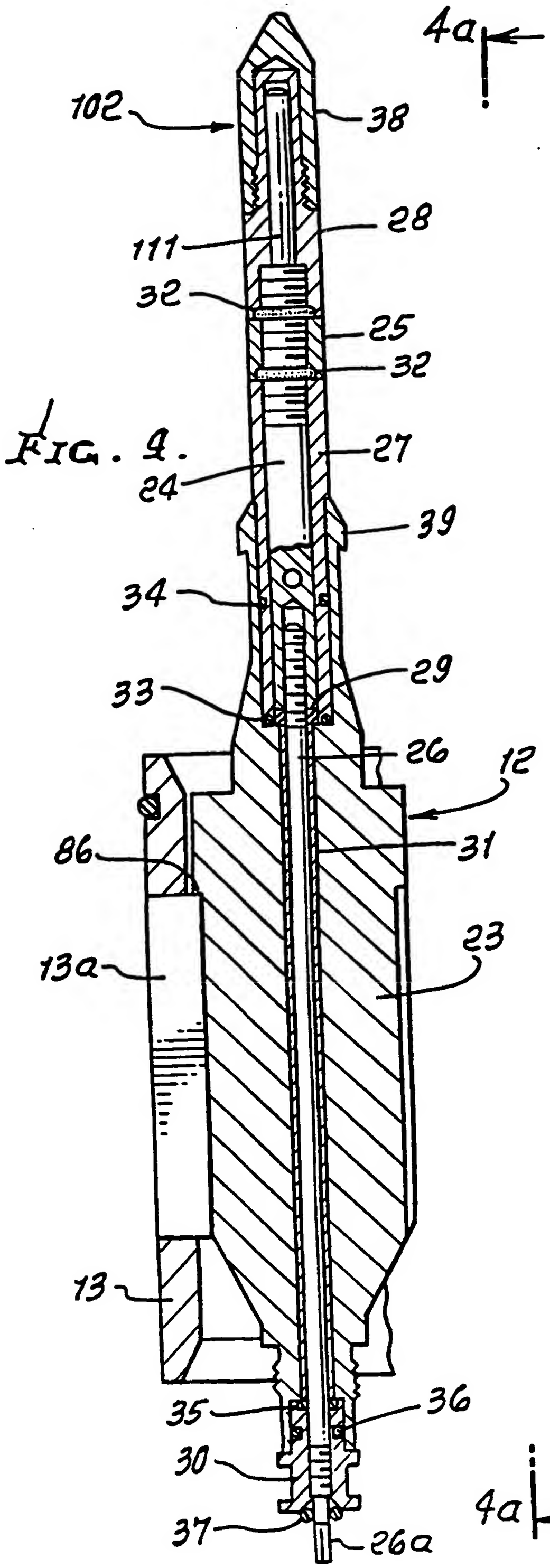

4a
102
38
28
111
32
25
32
27
24
39
34
29
33
26
12
86
31
23
13a
13
35
36
30
37
26a
4a

FIG. 1.

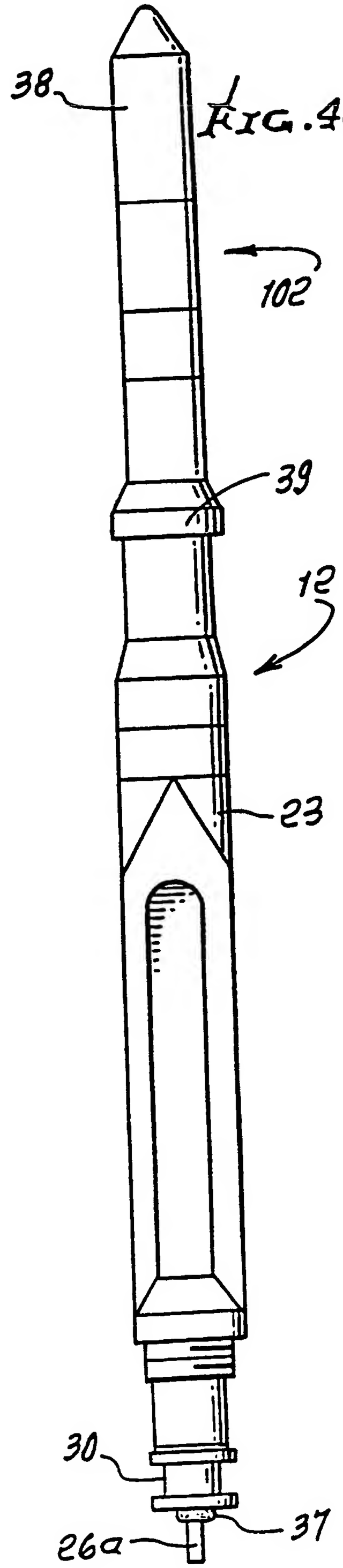

38
102
39
12
23
30
37
26a

FIG. 4a.

FIG. 5.

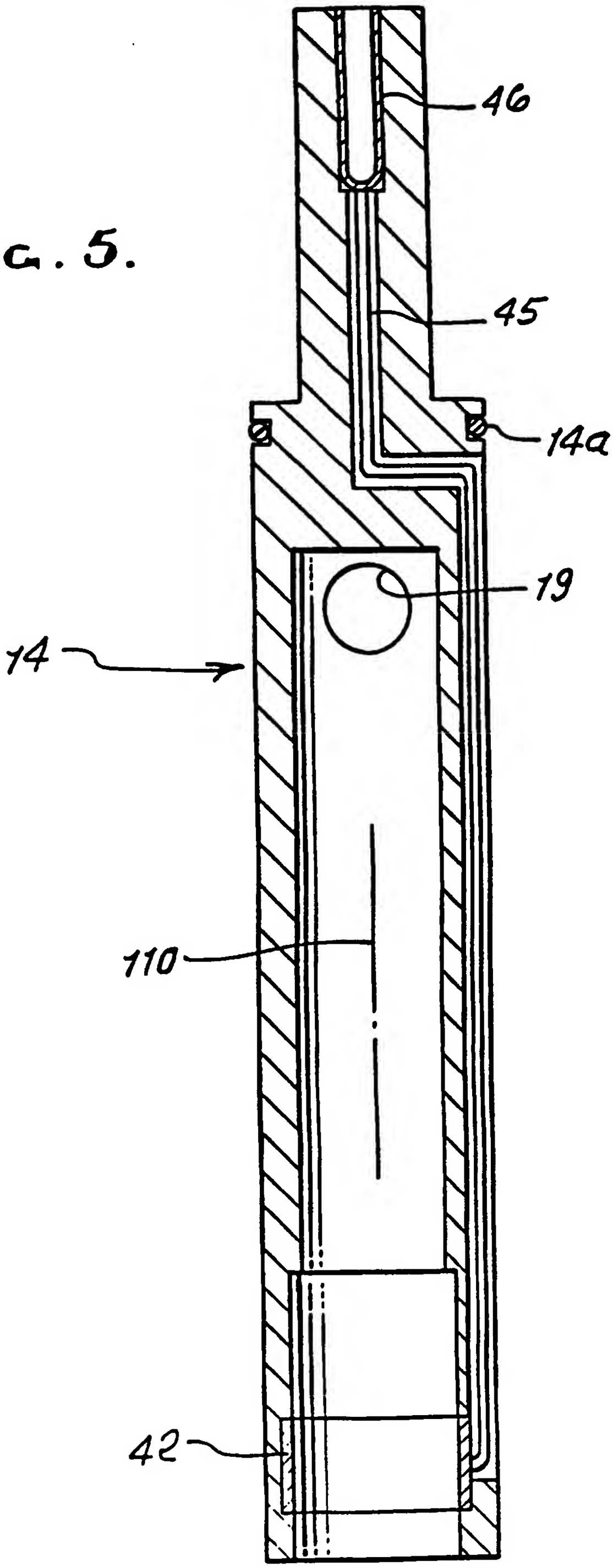


FIG. 6a.

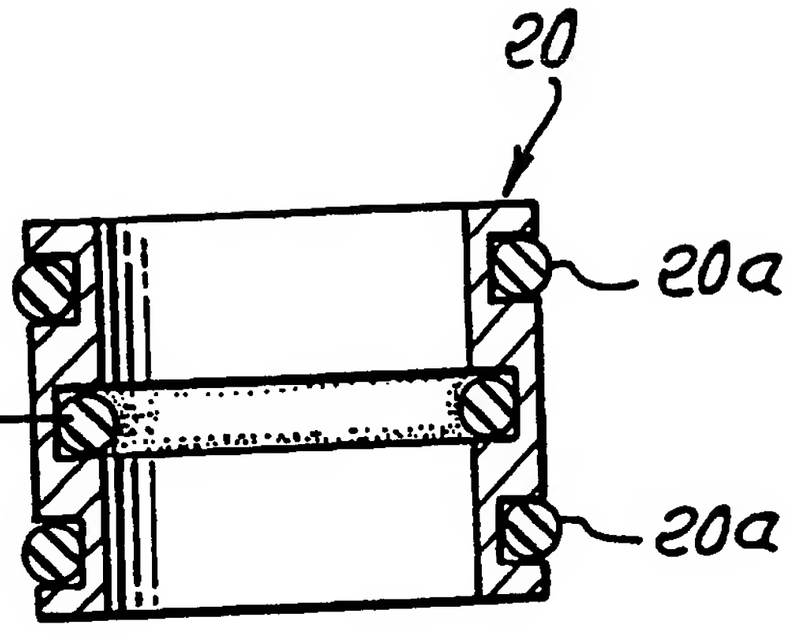


FIG. 6b.

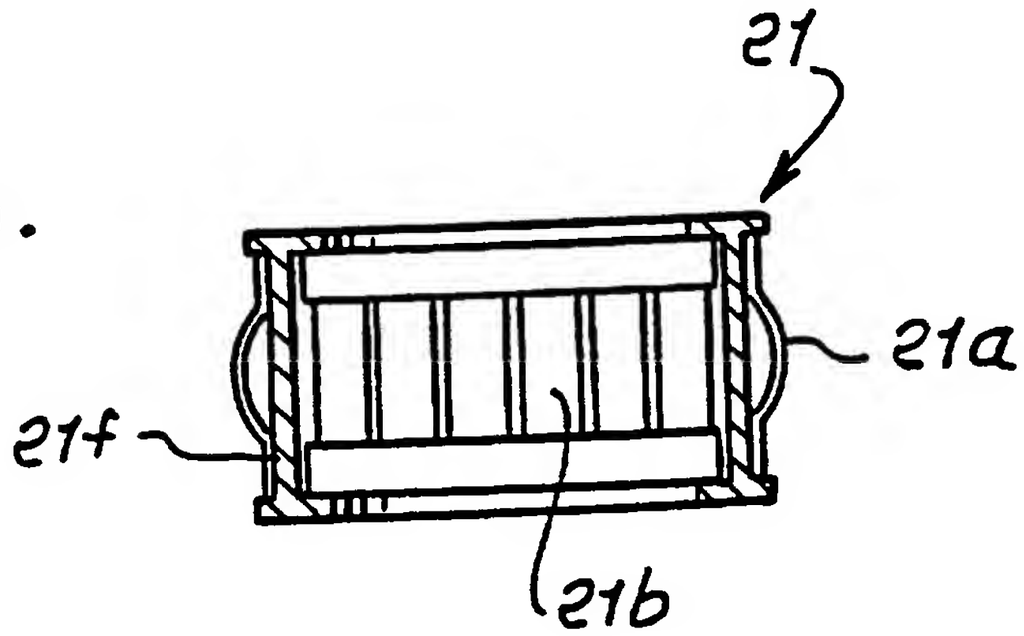
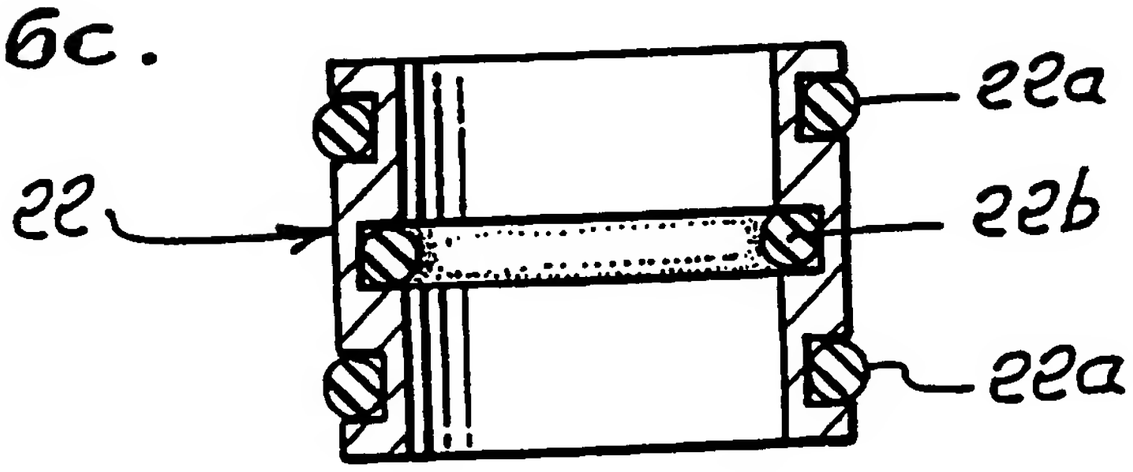


FIG. 6c.



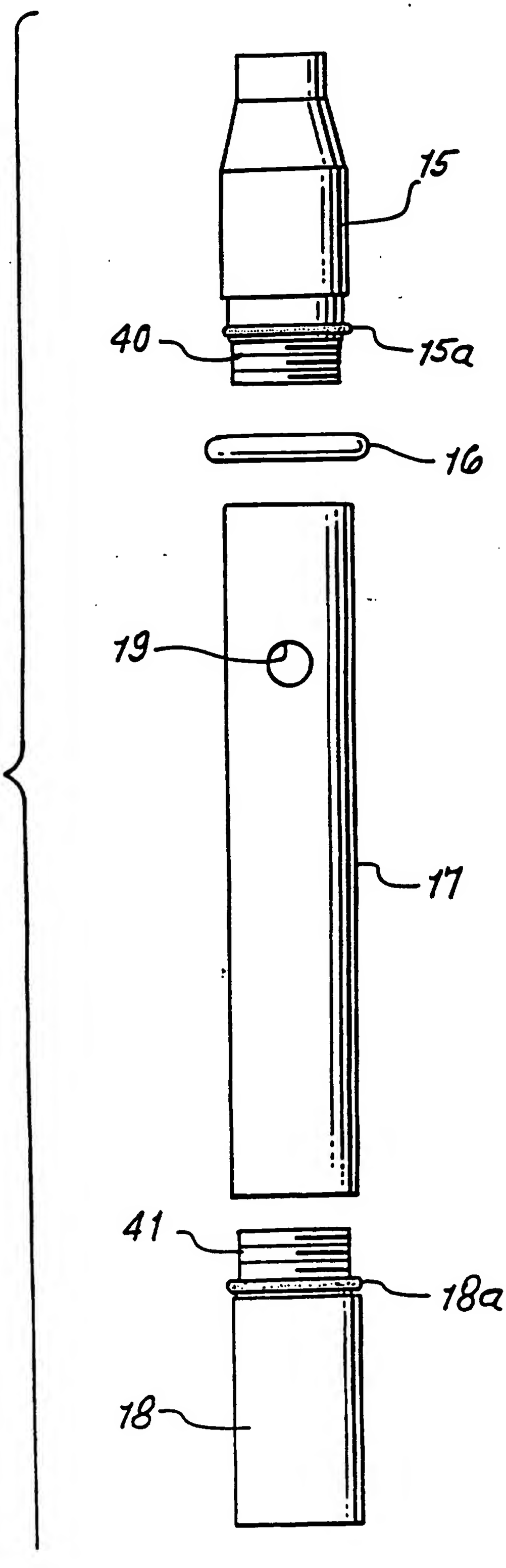


FIG. 7.

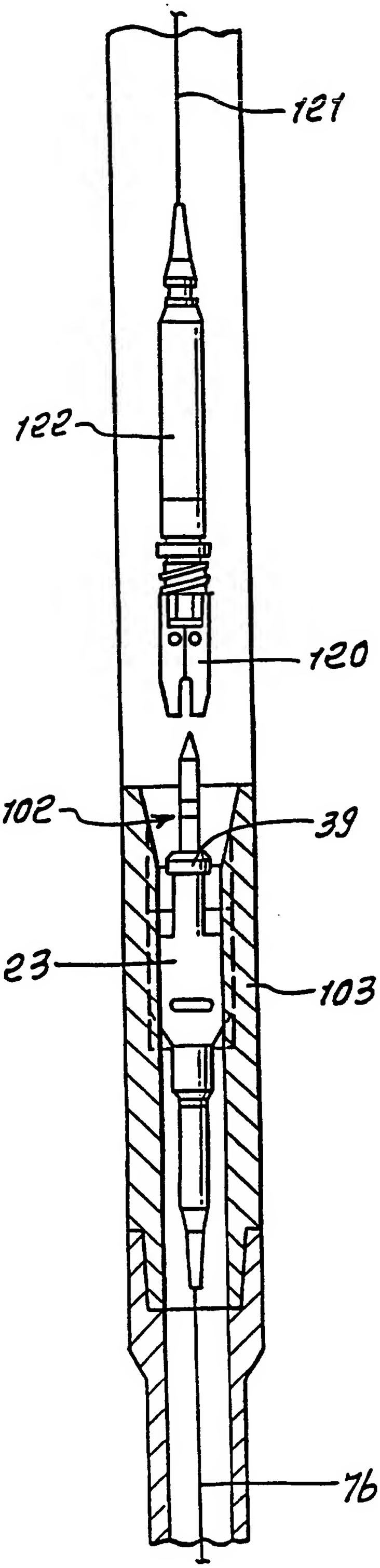


Fig. 8.

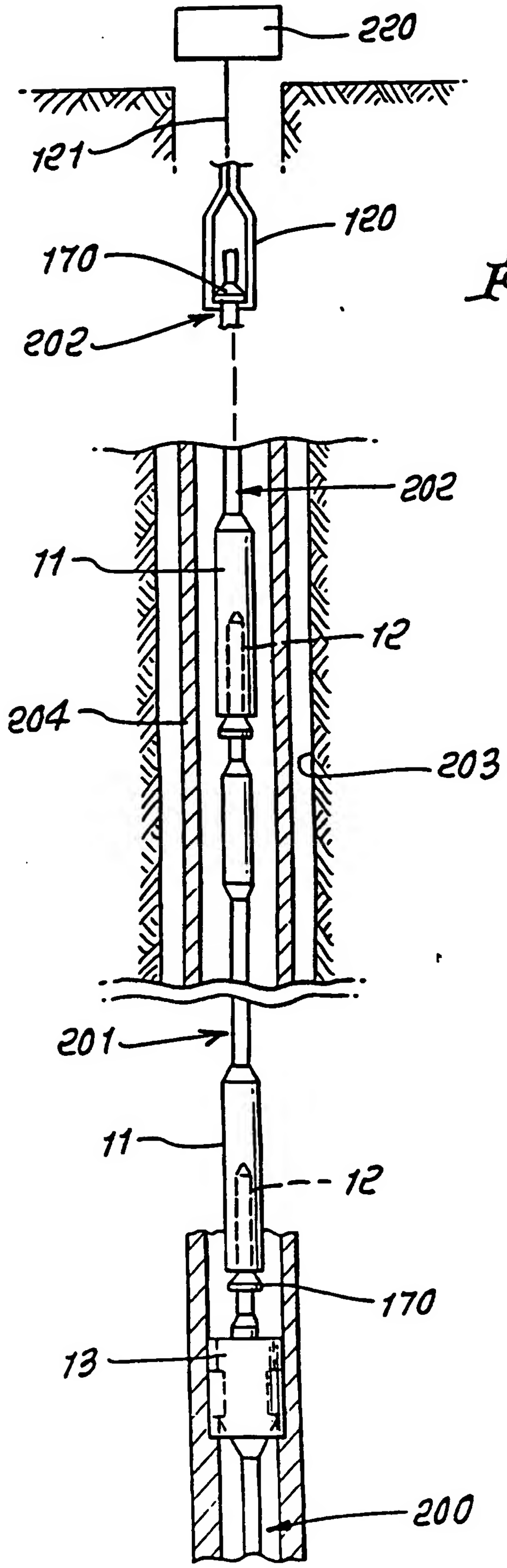


FIG. 9.

METHOD OF MAKING AND BREAKING ELECTRICAL CONNECTION

This invention relates to methods of making and breaking electrical connections.

Wirelines having an inner electrical conductor, a coaxial insulation layer, and an outer, protective wire covering, are in common usage in boreholes for connecting subsurface electrical equipment, for example, survey or steering tools, to surface electrical equipment. Such wirelines are generally routed from the wireline reel of the surface unit through a pulley or sheave at the upper level of a drilling rig, and may enter the drill string at the upper end, either through the rotary swivel, or other circulating head connections, down to the subsurface tool.

While drilling a borehole, it becomes necessary to add drill pipe sections to the drill string. In order to achieve this, any wireline within the drill string must be withdrawn to facilitate the addition or subtraction of the drill string elements. Withdrawal of the wireline and the attached tool may not be economical or easily achievable, especially in the case of very deep or highly deviated wells. The problems are further magnified in traversing the tool and wireline back into a highly deviated borehole, and effecting a reliable oriented seat at the bottom.

Furthermore, it often becomes necessary to have a combination of motor or slide drilling, and rotary drilling, in order to drill a directionally controlled well path. For these reasons, it is highly desirable to disconnect the upper section of the wireline so that it may be withdrawn only a short distance, while leaving the subsurface tool and a length of wireline in the borehole during the addition of drill pipe sections.

The present invention provides a method comprising:

a) providing a plurality of sections, each section including male and female members respectively at its opposite ends, the members of each section being electrically connected.

b) sequentially lowering the sections in the well to intercouple the male and female members of sequential sections, and thereby making electrical connection therebetween, for establishing electrical communication lengthwise in the well,

c) and sequentially raising the sections in the well to decouple the male and female members of sequential sections, thereby breaking the electrical connections therebetween, and for retrieving the sections from the well.

The intercoupling of the male and female members may be effected by lowering of the female member downwardly in the well, over the male member. Such members also typically have electrical contacts to come into interengagement, the method including the step of wiping well fluid from the contacts during intercoupling.

One embodiment further includes the step of releasing well fluid from an internal trapped fluid zone between the male and female members, as they interfit. In this regard, the lowermost section is typically landed in the well prior to sequential lowering of additional of the sections into the well. A landing support sleeve is typically provided on the drill string.

Yet another embodiment includes lowering a latching tool into the well to latch onto an exposed section, for raising the latter to release from the next below section. That tool typically includes an overshot, lowered over successively exposed male members, to latch onto shoulders during raising of the sections, successively, from the well.

Yet another embodiment of the present invention is to incorporate a tilt ring used in conjunction with weighted elements above the female member, and providing additional force to propel the wet connect female member downward, and allowing articulating freedom. It also guides and centers the entrance end of the female wet connect member to initially center itself relative to and about the male wet connect member, as for example in a highly deviated hole and to a degree approaching horizontal and beyond.

A still further embodiment of the present invention is the improved construction of the male member body, which typically has two or more arms extending out radially and configured to have locating slots in each extremity to accept a key and to be supported by the keys of the sleeve within the drill string. The keys have

rounded upper ends for matching engagement into the male wet connect body, and a tapered knife-like edge configuration for guidance of any male wet connect member below it, and also having a similar tapered leading edge, to avoid abutment on extraction from the drill pipe. The radial arm configuration presents passageways beside the male wet connect body for the free flow of drilling fluids.

The present invention may be used with a releasable and reseatable electrical connection within the borehole and within the drilling medium, for effecting an insulative electrical seal against the medium or any ground source. Generically, such a connection may be referred to as an "electrical wet connection".

The female (top) member may be provided which is mechanically and electrically connected to the wireline, with the wireline conductor being connected to a radial contact ring supported by insulators within its bore. In this embodiment, elastomeric seal gaskets, for example of an O-ring configuration, are located, such as to extrude drilling fluid as the female member is received downwardly over the male component, to seal against the intrusion of the drilling medium, and to insulate between potential ground. Also, the contacts are wiped clean during such reception.

The male (bottom) member may include an upstanding shaft fitted with a contact ring supported by insulators

and positioned to coact with the female contact ring once full engagement and seating takes place. The male member may be part of, or attached to, the subsurface tool, or to a separate entity, including support mechanism to hold it at a prescribed location in the drill string, and connected to the subsurface tool by a downwardly extending length of wireline.

Strength, durability, precision, and positive retention of all component parts, with radial holes in the connection apparatus providing an escape path or paths, for extrusion of drilling fluid during make-up, the outer housing being made of high-strength steel may be provided. The retained component parts can be easily removed, cleaned and separately replaced, thus assuring absolute sealing and operation.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following specification and drawings, in which:

Fig. 1 is a schematic view of a borehole drilling operation showing the borehole, a wireline, the subsurface, and the surface equipment;

Fig. 2 is a partial and enlarged cross section taken through wet connect members, shown mated together, and supported in a typical support sleeve

within the drill string;

Fig. 2a is a section taken on lines 2a-2a of Fig. 2;

Fig. 2b is a perspective view of a support sleeve;

Fig. 3 is a cross section taken through the overall female member of the wet connect;

Fig. 4 is a cross section taken through the male member of the wet connect;

Fig. 4a is an elevation taken on lines 4a-4a of Fig. 4;

Fig. 5 is a cross section showing the insulative body of the female member together with the encapsulated electrical wiring;

Fig. 6 is a cross section showing in 6a, 6b, and 6c the insulative bushings and the contact ring;

Fig. 7 is an exploded view of the component parts of the outer housing of the female member;

Fig. 8 is a schematic illustration; and

Fig. 9 is a schematic illustration of multiple electrically connectible sections in a well.

Fig. 1 shows a drilling rig 1 on the surface of the earth 2 for drilling a borehole 3 into the earth. The drilling is accomplished by a drill bit 4 at the bottom of the drill string made up of individual drill pipe sections 5. As part of the drill bit and drill collar assembly at the bottom of the string, a steering

or survey tool 6 is provided for measuring the direction and inclination of the borehole.

An upper wireline indicated at 7a is spooled on a reel 8, which is part of the surface equipment, and is generally controlled and operated by a motor drive. The wireline section 7a passes over pulleys or sheaves 9 associated with the rig and extends downwardly into and through drill pipe sections 5 to a wet connection to connect to a lower wireline section 7b, which in turn extends to the subsurface tool. The purpose of the overall wireline is to carry power and signal data between the tool 6 and surface equipment 10. The reel 8 unwinds, playing out the wireline as the drill string penetrates further into the earth. The wireline is wound back on the reel 8 when it becomes necessary to extract it and the tool 6, allowing drill string sections to be added, or removed, from the borehole. The surface equipment 10 is connected to the wireline at the reel 8.

For several purposes, it is desirable to have a "wet connection" in the wireline that may be easily disconnected, so that only the upper section 7a of the wireline may be withdrawn, leaving the tool 6 seated or located in place at the bottom of the drill string, but connected to the male member of a wet connect in the string near to the surface of the earth, by a length of the subsurface wireline 7b.

Figs. 2 and 2a are enlarged views of the engaged wet connect assembly of female 11 and male 12 members. The assembly is supported within a support sleeve 13 configured to accept the body of the male

member into keys 13a. Sleeve 13 in turn seats at a shoulder 80 formed by special section 103 in the string 5.

Referring also to Fig. 3, showing a female upper member 11 in section, an insulative body 14 is assembled in an outer housing comprising components 15, 16, and 17. A sealing gasket 15a, preferably of an O-ring configuration, is incorporated at a pin and box connection between 15 and 17, to prevent drilling fluid from entering the housing. Holes 19 are provided through the housing wall or walls for escape of the drilling fluid from body bore 84 during subsequent reception of 12 into 84. See arrows 84a. This feature also permits self-flushing, while traversing within the drill pipe, as well as subsequent cleaning of internal components. An insulative bushing 20 is fitted with outward seals 20a and inward seal 20b, for example of an O-ring configuration, and inserted into the body 14. See also Fig. 6. A contact assembly 21 carried by 14 below 20 is located dimensionally over a mating contact ring 21b encapsulated into the body 14. A second bushing 22, fitted with outward seals 22a and inward seal 22b, is also inserted into and carried by body 14. All items have precision fit and are positively locked in place with housing skirt 18 incorporating a sealing gasket 18a between the pin and box connection between 18 and 14, to prevent drilling fluid from entering the housing.

Referring now to the male member 12 seen in Fig. 4, a high-strength steel body 23 fits into and is supported at shoulder 86 by the keys 13a of a support

sleeve 13 also shown in Fig. 2c. The body 23 has two or more such key engagements providing as many passageways or openings 104 between body arms 101 to allow circulation of drilling fluids through the drill string. See Fig. 2a.

The body 23 houses an upwardly directed probe 102, which is centrally supported and strengthened by a conductive center rod 24. Electrical connection to the female contact is radially established at a precision contact ring 25 threaded on the center rod 24. Conductivity is further transmitted down through the body 23 by means of a conductor rod 26, threaded into the center rod 24, and terminated appropriately at the lower end, for connection to equipment below it.

The conductive components 24, 25, and 26 are insulated from the body 23, and other ground potentials by insulators 27, 28, 29, 30, and 31, each of which is made of an insulating material, such as PEEK, later referenced in this text.

The insulator sleeve 27 is precision fitted about and screwed onto the center rod 24 with a gasket 32, preferably of an O-ring configuration, making a leak-tight seal with the contact ring 25. The insulator cap 28 is precision fitted about the upper part of the center rod 24, thread connected to it, and sealed in a like manner to the insulator sleeve 27, with a gasket 32.

The insulated center rod 24 is further insulated by means of an insulative spacer 29 and sealed with a gasket 33, preferably of an O-ring configuration. In this embodiment, a second radial gasket 34 is

optionally employed in similar manner.

The conductor rod 26 may be insulated with material, such as DuPont polytetrafluoroethylene (TFE) Teflon tubing 31. The rod 26 is further insulated at its lower or exit end 26a with an insulator nut 30, sealed with a gasket 36, preferably of an O-ring configuration. In this embodiment, a second radial gasket 35 is optionally employed in the same manner.

A similar seal gasket 37 is provided for subsequent sealing to any attachment designed for the application.

The probe upper extremity is equipped with a protective cap or helmet 38 screwed onto the uppermost insulator cap 28, manufactured of a hard, high-strength material for strength and durability. The helmet 38 is conical in shape at its upper end to assist in centering during reception into wet connect female member 11. At that time, drilling fluid in bore 84 of member 11 is squeezed out via passages 19.

The body 23 is additionally equipped with a fishing neck or flange configuration at 39, to facilitate retrieval using either a conventional "overshot" in usage in the industry, but modified with an enlarged cylindrical recess to accept the elongated probe section 25, or by a specially fitted overshot designed for the present application.

Fig. 5 shows an axial cross section of the insulative body 14 of the female member rotated relative to Fig. 3, to illustrate the electrical conductor 40 routing from the upper electrical connection point 41 (to

wireline 7a) to the contact ring 42 embedded within its lower confines. See Fig. 7, which also illustrates the aforementioned radial exhaust ports or holes 19 for the drilling fluid to escape.

The body 14 is made from an insulating material having excellent electrical insulating properties, mechanical strength, and dimensional stability at the elevated temperatures that may be encountered in boreholes. One suitable material is Victrex PEEK 450GL30, available from the Polymer Corporation, P.O. Box 422, Reading, PA. This material consists of glass fiber-filled polyetheretherketone.

Elements 6a to 6c of Fig. 6 are now referred to. Fig. 6a shows an axial cross section of the insulative bushing 20, together with its gasket seals 20a and 20b, as used above the Fig. 6b contact ring 21 for positioning and sealing purposes. The conducting ring 21, as illustrated in Fig. 6b, consists of a bow spring element 21a wrapped about a conductive cylinder 21f, and bowed outwardly to make positive pressural electrical contact with the contact ring 42 embedded in the insulative body 14, and a conductive inner spring element 21b captive within the inner diameter of the cylinder, and bowed toward the second axis 110. Once engaged, the inner spring element 21b makes absolute electrical contact with the mating and coacting contact ring 25 of the male probe member, extending about the male member first axis 111. Axes 110 and 111 align during make-up.

Fig. 6c shows an axial cross section of an insulative bushing 22, like that of Fig. 6a, together

with its gasket seals 22a and 22b, for use below the contact ring 21, for positioning and sealing. Seals 20b and 22b wipe and seal against the outer cylindrical surface of the probe 102 and protect 21b and 25. The bushings 20 and 22, made of the insulating material PEEK, are identical to that used in the body 14, and incorporate their respective sealing gaskets of an O-ring configuration to seal against the body 14 and provide a wiping seal for the male probe member, both above and below the conducting ring engagement.

Fig. 7 shows a view of the external housing component parts, including rope socket 15, tilt ring 16, housing 17, and skirt 18. The rope socket 15 in this embodiment has a special rope end configuration, and is screwed (see thread 40) into the housing 17 capturing the tilt ring 16 between them, and incorporating a seal gasket 15a. The skirt 18 is screwed (see thread 41) in place into the housing 17 lower end, after all the internal components are assembled to the housing 17. A seal gasket 18a, like 15a, is employed to seal off between 18 and the lower end of 17. These outer housing components precisionally confine the electrically insulating and conducting components, providing a cylindrical high-strength metallic housing. The external tilt ring coacts with and allows the female member 11 to self center, relative to the housing in both near vertical and highly non-vertical, i.e., deviated boreholes.

In operation, the member 12 is carried by the support sleeve 13 in a vertical section of the drill

string, near, i.e., below the drilling rig. The member 13 is lowered in the bore of the string section to receive the member 12 and any drilling fluid therebetween is squeezed out endwise during make up. Seating occurs at mating conical surfaces seen at 110 and 111 in Fig. 2. The contact ring 25 is thereby brought into engagement with the inner spring element 21b on 13, to establish electrical contact, despite a film of fluid adjacent these elements. The wireline is, accordingly, brought into operative connection, for power and signal data transmission, member 12 being connected via wireline 7b to 6.

When drill string is to be removed from the hole, the upper wireline 7a is pulled up, detaching member 13 from member 12, and removing 13 from the upper string section. An overshot can then be lowered to connect to member 12, as via neck 39, as referred to above, so that the wireline can be removed. Then, all the drill string sections can be pulled from the hole.

Fig. 8 schematically shows an overshot 120 being lowered on a line 121 to attach neck 39, as referred to above. Overshot body 122 is connected to 121.

Referring to Fig. 9, it shows a series of like sections 200, 201 and 202 in a well 203 containing a drill string 204. The sections 200--202 are made up in a series sequence, and the sections are alike, with a wet connectible male member 12 at the upper end of the section, and a wet connectible female member 11 at the lower end of the section. Members 11 and 12 may have the

construction as described above. Members 11 and 12 of each section are electrically connected in the sense also described above, i.e., they contain electrical elements that are electrically connected from one end of the section to the other. The method of sequentially making and breaking electrical connections between male and female members, as described above, and at intercoupled locations, and according to the present invention includes the steps of

sequentially lowering the sections in the well to intercouple the male and female members of sequential sections, and thereby making electrical connection therebetween, for establishing electrical communication lengthwise in the well, to establish communication with a tool deep in the well; and

sequentially raising the sections in the well to decouple the male and female members of sequential sections, thereby breaking the electrical connections therebetween, and for retrieving the sections from the well.

Thus, section 200 is first lowered and landed at sleeve 13 in the string, as by using latching tool 120 grasping flange 170 on a male member 12 on section 200, and lowering line 121. Next, tool 120 is employed to lower the next in sequence section 201 to lower female member 11 of 201 onto male member 12 of 200; and the sequence is repeated for section 202 and further up sections. Electrical connections are thereby made through the entire sequence of sections 200--202, etc., to provide electrical continuity between survey tool 6 and the wellhead, as indicated at 220.

In like manner, the sections are sequentially

raised, i.e., raise 202, then 201, then 200, to decouple the members 11 and 12, at each wet connection, when the sections are to be removed. This process enables successive drill string pipe stands to be connected into the string at the wellhead, and successive electrical continuity sections to be sequentially lowered, landed, and made up in the well, and within the string, eliminating need for pulling all the electrical continuity sections from the well when drill string sections are added.

Note that well fluid becoming trapped between members 11 and 12 is released or flushed, as the members 11 and 12 are made up, and wiped together to establish good electrical connection.

Raising of the sections typically includes lowering of a latching tool into the well to latch onto an exposed upper section, for raising that section to release from the next below section. Also, latching of an overshot to a section involves deep lowering of a latching tool onto and over a member 12 to grasp the flange 170, and for raising or lowering the section.

In the above, it will be noted that each male member body with its attachments therebelow is individually retrievable axially through the sleeve and key assembly thereabove.

Further, multiple sets of wet connect components are provided at selected locations within the drill string, as the bore hole depth increases, to maintain a short distance of wireline withdrawal during drill pipe connections. To facilitate subsequent

extraction of the multiple components, the male wet connect body has knife-like, upper edges to deflect the body on engagement with the similar knife-like edges at the bottom of the support keys, thus allowing it to pass between the keys unobstructed.

As the borehole is drilled deeper, it becomes economically feasible to add an intermediate section or sections of wireline to reduce the length of the upper section of the wireline being traversed into the borehole.

CLAIMS

1. A method comprising:

a) providing a plurality of sections, each section including male and female members respectively at opposite ends thereof, said members of each section being electrically interconnected;

b) sequentially lowering the sections in the well to intercouple the male and female members of sequential sections, and thereby making electrical connection therebetween, for establishing electrical communication lengthwise in the well,

c) and sequentially raising the sections in the well to decouple the male and female members of sequential sections, thereby breaking the electrical connections therebetween, and for retrieving the sections from the well.

2. The method of claim 1 wherein said intercoupling of the male and female members is effected by lowering of the female member downwardly over the male member.

3. The method of claim 2 wherein the male and female members have electrical contacts to come into interengagement, and including the step of wiping well fluid from said contacts during said intercoupling.

4. The method of any preceding claim wherein well fluid becomes trapped between said members during said intercoupling, and including the step of releasing the trapped well fluid during said intercoupling.

5. The method of any preceding claim including landing a lowermost section in the well prior to said sequential lowering of additional sections into the well.

6. The method of claim 5 including providing a support sleeve in a drill string in the well, said landing of the lowermost section effected by landing onto said support sleeve.

7. The method of claim 1 wherein said raising of the sections includes lowering of a latching tool into the well to latch onto an exposed section, for raising that section to release from the next below section.

8. The method of claim 7 wherein said latching tool includes an overshot, and said lowering includes lowering the overshot over successively exposed male members, to latch onto shoulders associated with said male members, during said raising of the sections, successively, from the well.

9. The method of any preceding claim including

c) providing the male member to define a first axis and to have an externally exposed electrical contact ring, extending about that axis,

d) providing the female member to define a second axis and to have a conductive part extending at least part way about that second axis, and to have a spring element in electrical connection with said part and inwardly exposed for making electrical contact with said contact ring upon telescopic interfitting of the members.

10. The method of claim 9 including providing a housing for the female member and a tilt ring thereon to cooperate with the drill string for allowing self centering of said housing and alignment with at least one of the members.

11. The method of claim 9 or 10 including providing insulative bushings on the female member and that extend about said second axis above and below said conductive part for locating engagement with the male member upon said telescopic interfitting.

12. The method of any one of claims 9 to 11 wherein said conductive part is annular, and said spring is provided to comprise a bowed element carried by said annular part to tightly engage said contact ring.

13. The method of any one of claims 9 to 12 including providing a support sleeve and key assembly to support said male member to seat on a shoulder within said drill string.

14. The method of any preceding claim including employing a tilt ring to assist in guiding intercoupling of the members.

15. The method of any preceding claim including employing radially extending arms in association with the male member to interact with keys associated with the female member for guidance of relative axial movement of the members.

16. A method of making and breaking electrical connections between a series of electrical continuity sections in a well substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9522260.0
Claims searched: 1 to 16

Examiner: D.B.Pepper
Date of search: 8 January 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): E1F FHK.

Int Cl (Ed.6): E21B.

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 94/23176 A (Carmichael)	1,2,5-8
X,P	US 5389003 A (Van Steenwyk et al)	1-16
X	US 5141051 A (Lenhart)	1,2,5-8
A	US 3807502 A (Heilhecker et al)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.